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"A DECADE OF ACHIEVEMENT"

MARINE TECHNOLOGY SOCIETY

UNDERWATER SECURITY VEHICLE PROOF OF CONCEPT DEMONSTRATION

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ABSTRACT

The Underwater Security Vehicle (USV) program, sponsored by the Defense Nuclear Agency, successfully demonstrated the feasibility of using a remotely operated underwater vehicle system to assess designated diver contacts in a near-shore environment. The demonstration system was a Benthos Super SeaROVER vehicle equipped with a Smiths Hi-Scan 600 sonar. Over a two month period, general operating parameters of the system were determined. The system performed well overall, aptly demonstrating the capabilities to acquire, track, and intercept diver targets. In addition to formal testing, the USV capabilities were demonstrated during a Coast Guard harbor defense exercise in August 1991. Based on the tests performed, additions of a wide-angle field of view sonar and a navigation system are recommended for an effective operational security asset.

1.0 INTRODUCTION

1.1 Objective

The objective of the Underwater Security Vehicle program was to evaluate the feasibility of using an underwater remotely operated vehicle (ROV) system as an aid to underwater security. The USV system was designed to be used to assess designated contacts in a near shore environment, augmenting existing security systems such as the Waterside Security System (WSS).

1.2 Need

An underwater security system is required to protect against underwater threats to critical waterside or waterborne assets such as weapon depots, loading areas, power plants, ships, and submarines. Threats may take the form of swimmers, scuba divers, and swimmer delivery vehicles. Use of a ROV can enhance existing systems providing for the detection, assessment, and response to underwater threats.

1.3 Approach

Four concepts of ROVs for underwater security were developed based on threat analyses and investigation of Fleet requirements [Fletcher 1991]. By direction of the program sponsor at the Defense Nuclear Agency, it was determined that the USV would be developed as an assessment adjunct to the WSS system. Based on the scope of the effort, the USV program was directed to use commercially available, off-the-shelf equipment for the proof of concept demonstration.

1.4 Mission Description

The USV is intended to serve as an adjunct to the WSS or other security system. Figure 1 depicts the USV system concept, showing how the vehicle would be used as an additional sensor carried on a patrol boat responding to a target detected by another system. Figure 2 depicts the operational sequence planned for the USV system. Once a contact is made by the detection sensors, the USV will be deployed from a patrol boat or other support craft at the contact location. The operator will acquire the target on the vehicle sonar, and use that information to vector the vehicle into visual contact range of the target. Video from the USV will be used by the operator to assess the target and to determine the appropriate course of action. The current USV does not have any initial detection or response capability, being intended solely as an aid to target assessment.

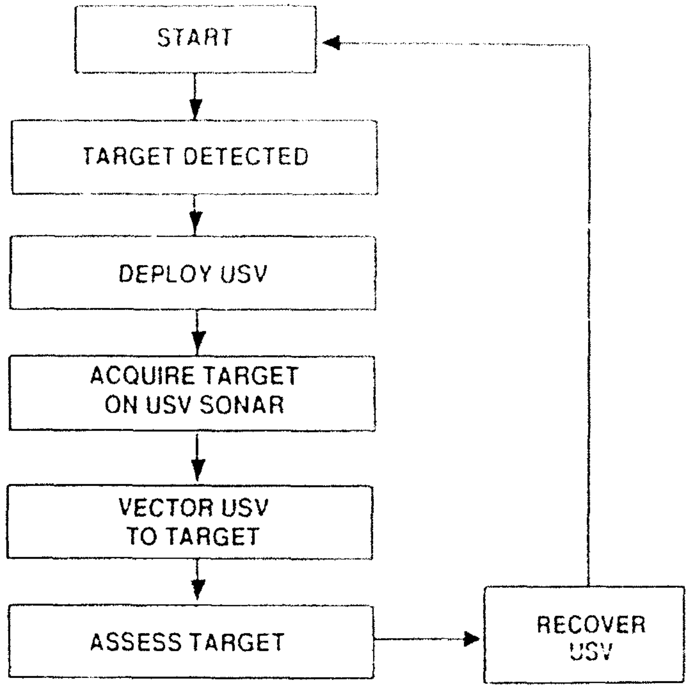

Figure 2: Operational Sequence

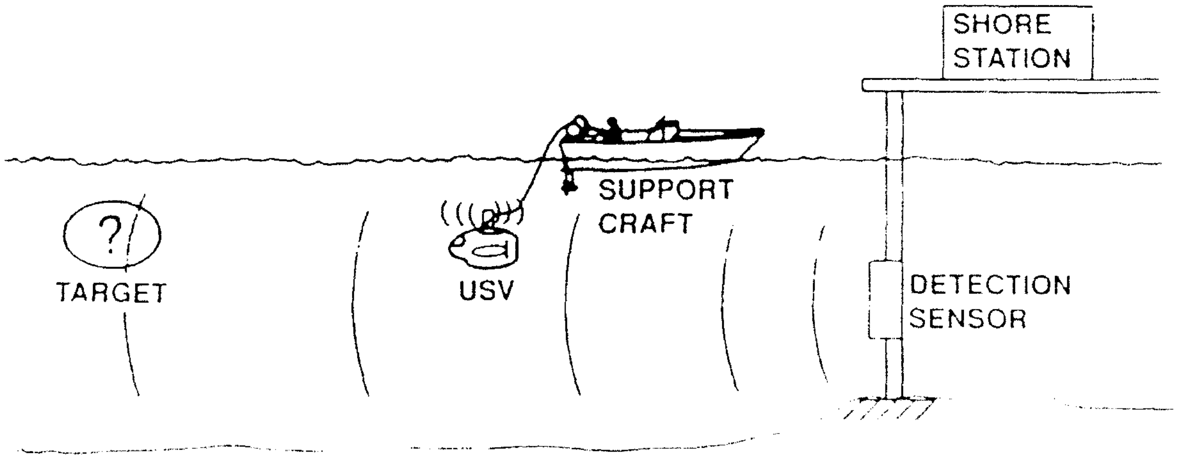

Figure 1: USV System Concept

2.0 USV SYSTEM DESIGN

2.1 Commercial ROVs

A series of demonstration tests were held in January-February 1990 to evaluate the capabilities of a range of commercially available ROVs [Nobunaga 1991]. Five companies participated: RSI Research with SEAMOR, Sachse Engineering Associates with Sea Search MK II, Perry Technologies with SPRINT 101, Benthos with SUPER SeaROVER, and Deep Ocean Engineering with PHANTOM SS4. Each system was evaluated on four major areas: physical characteristics, human factors, vehicle performance, and sensor performance. Both the Super SeaROVER and Phantom SS4 performed well within the desired USV operating ranges. The Smith's Hi-Scan 600 sonar was considered by far the best sonar choice for the USV system due to its high scan rat (8x/second), clear display, an ease of use under the require dynamic operating conditions.

2.2 USV System Description

Based on the missio requirements and availabl systems, a specification wa developed for the USV Proof o Concept System. The syste procured consisted of a Bentho Super SeaROVER vehicle (figur 3), 1100' of 0.7" diamete tether cable, a contro console, a hand controller, power conditioning console, monitors, and an 8 kilowat generator. System consoles an monitors are operated directl from their respective shippin cases where they are shoc mounted in 19 inch racks. Th system is designed to be easil transported and operated off variety of platforms such a small piers or patrol boats.

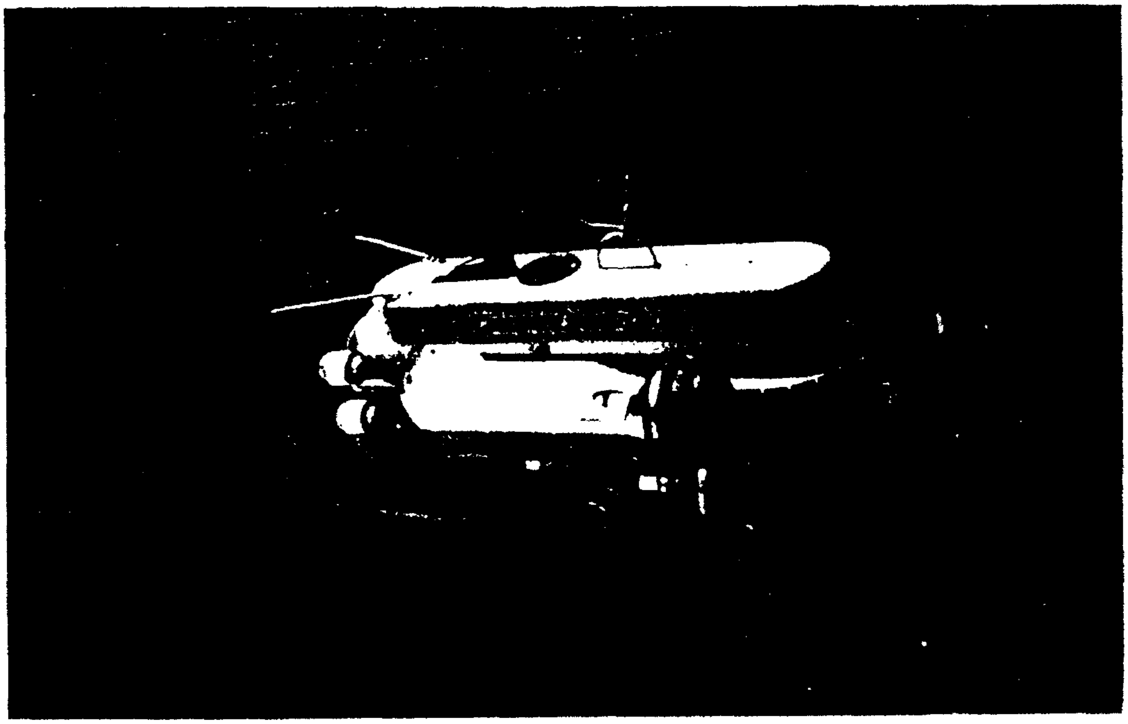

Figure 3: The USV Vehicle

3.0 USV TEST AND EVALUATION

3.1 Target Detection

The first series of tests performed were to determine the target acquisition characteristics of the USV system. Specific factors measured were target depth, type, and orientation. The best operating procedures and vehicle maneuvers were determined in order to maximize the target acquisition range.

In an actual operational scenario, the position of the target in the water column will not be known. Therefore, the first test was to determine the optimal operating depth of the vehicle for the full range of target depths in 6 m water depth. Figure 4 shows the detection ranges for varying vehicle depths on different target depths. The maximum

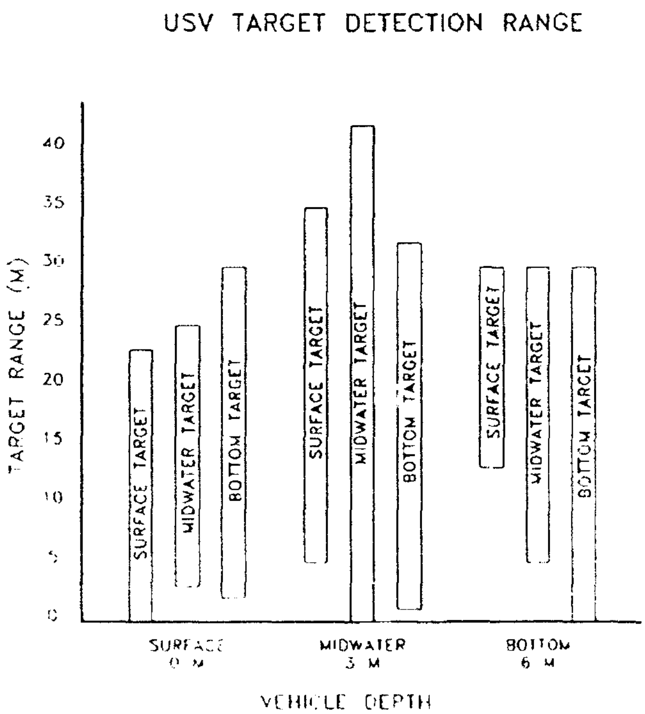

Figure 4: Detection Results

range achieved was 42 m. for a midwater target detected by a midwater vehicle. The limit on the near ranges was due to the target falling outside of the 30 deg x 10 deg cone of the sonar beam. Based on these results, it was determined that the best operating position for the USV was in the midwater position to achieve the maximum detection range for the full range of targets. In deep water (>30 m), this should be interpreted that the vehicle is operating in the midrange of where the target is expected (ie: surface to 30 m).

Based on the tests run and the Coast Guard harbor defense exercise (section 3.3), it was found that the type and orientation of the targets did not noticeably affect the detection ability. In the formal tests, both a dummy wetsuit and live divers using open circuit scuba were used, with no apparent difference in detectability. Similarly, the Navy SEALS in the harbor defense exercise provided very clear targets despite the use of closed circuit scuba. This performance indicates that the USV is an effective detection tool for diver targets in an operational environment.

3.2 Tracking and Interception

The second series of test runs were to determine the performance of the system in tracking different target behaviors such as speed and path. During formal testing, 15 runs of targets following varying speeds and paths were made, with the vehicle making visual contact with the target or bubbles 11 times, a 73% success rate.

The speed of the target did not appear to have any effect on the ability of the vehicle to acquire the target. Divers were towed on a known course and bearing at speeds of 0.5 and 1 knot, and there was no difficulty in acquiring, tracking, and intercepting them. As the vehicle top speed was measured at 3.1 knots, it is unlikely that an unassisted diver would be able to outswim the vehicle.

The target divers were given a variety of paths to swim, including straight compass courses, dog legs, varying depths, near bottom, erratic patterns, and full-on evasive maneuvers. At any given time, the target course was unknown to the vehicle operator. Two major tracking difficulties were found: one, the narrow sonar beam made following erratic path changes difficult particularly at close range, and two, it was very easy to overshoot a target. As the sonar does not give target depth information, once the vehicle is close, a target may be directly above or below the vehicle, thus out of the sonar cone. If a target was below the vehicle, often the bubbles would be detected, indicating the location and nature of the target. However, if the vehicle was below the target, it was easy to pass, losing the track.

The system performed well overall, aptly demonstrating the capabilities to acquire, track, and intercept diver targets. It should be noted that these tests were all performed with vehicle and sonar operators with less than 10 hours of operational time, indicating the usefulness of the system even in relatively untrained hands.

3.3 Proof of Concept

In addition to the tests described above, the capabilities of the USV system were demonstrated during the Coast Guard Maritime Defense Zone OPS 91 harbor defense exercise on 10-11 August 1991. The vehicle system was used to augment the in-water security at Barber's Point Harbor on the island of Oahu. The vehicle was operated from a platform off the NW end of the protected area, so that the approach could be scanned with the sonar.

The system was deployed and in the water at approximately 2345 on 10 August. In-water visibility was poor at approximately 1 foot, but excellent sonar images were received from the jetty and the base of the dry dock. The vehicle was placed in an outward looking position, roughly 50 feet from the deployment platform at the designated midnight starting time.

Once in position, the operator demonstrated the vehicle's capability to yaw and scan a wider area than the 30 degree sonar beam. At 0025 hours, a sonar contact was made at a range of 25 meters. The vehicle was driven to intercept the target, using the sonar to maintain contact. At a range of approximately 3 meters, sonar contact was lost. The vehicle lights were then turned on to illuminate the target from below. At this point, the target reappeared on the sonar and was again tracked to within 2-3 meters. Lights were again turned on, and the target(s), two Navy SEALS on closed circuit scuba, were located on the surface by security personnel. While no visual contact was made from the vehicle, it was clear by the action of the sonar contacts that the targets were of interest, providing the required assessment function.

Upon debriefing, the divers stated that they were aware of the presence of the vehicle due to the sound of its thrusters, but they were unable to determine its location. They stated that they knew they had been detected and their mission compromised since the vehicle followed them around and shone the lights on them. At that point they came to the surface and conceded defeat.

4.0 USV SYSTEM RECOMMENDATIONS

4.1 Vehicle

The Super SeaROVER vehicle is a compact system to carry the sensors required by the USV system. However, the hard hat configuration makes it awkward to service and troubleshoot the system. For a Fleet system, simpler access to the major subsystems would be highly desirable.

The response of the vehicle was excellent, perhaps even excessive. Given a yaw command, the vehicle could turn very rapidly, faster that the compass response. This often resulted in overshooting the target and difficulty in maintaining a desired heading. Similarly, external effects such as current and tether pull, could greatly affect the vehicle heading. Faster compass response would allow the operator to make full use of the vehicle capabilities.

4.2 Sonar

The high update rate of the Smiths Hi Scan 600 sonar proved to be invaluable for tracking moving targets while based on a moving platform. The high resolution allowed for the determination of diver-like targets and their subsequent tracking and interception. However, the narrow field of view (30 degrees horizontal and 10 degrees vertical) made it difficult to initially acquire a target or to follow one that was rapidly changing course. The addition of a sonar capable of covering a 180-360 degree area, even at a speed slower than the Smiths, would enable the system to perform this acquisition role more efficiently. The target could be detected initially by the additional sonar, giving the operator the proper bearing to direct the vehicle. Once the vehicle is pointed in the correct direction, the Hi Scan sonar may be used to track and intercept the target. Similarly, if the target is overshot, a slower, but wider field-of-view, sonar can be used to determine the proper bearing for a return.

An additional difficulty with the sensor suite was the lack of target depth information. Currently, there are no commercially available sonars which would provide 3-dimensional information of this type. However, there are sonars in development which would address this requirement.

Another possibility to expand the effective swath width and depth capability of the Hi Scan sonar would be to mount the sonar head on a pan and tilt device. This could be run similarly to the video pan and tilt with the degree of pan and tilt indicated on the sonar display. It would be desirable to have the control stick spring loaded to the center of the pan position, to insure a forward view unless otherwise directed. Ideally, the pan and tilt information could be integrated with the vehicle heading and depth to provide the operator with direct information as to how to direct the vehicle to intercept the target.

4.3 Video

In the harbor environment, video was of little use until the target was closely approached, due to the poor water visibility. No video cameras or telemetry can produce a picture at a range beyond that of the water visibility. Some of the current work in laser scanner imaging shows promise for application to the USV mission area.

4.4 Navigation

Due to financial constraints, no positioning system was installed on the USV system. An ORE Trackpoint II system was used with the vehicle during the initial operator training, vividly illustrating the need for knowing where the vehicle is relative to the host platform. With an integrated navigation and security system, it would be possible to show the vehicle position relative to the target as well.

4.5 Operational Considerations

For operational use, it would be highly desirable to have a single operator, rather than the two or three now required. To do this efficiently, the video and sonar information should be available on a single display. This could be done with a window technique whereby there is a major display with a small window of the alternate sensor information. As video is of limited use until one is in close range to the target, the sonar would be the primary image with the option to switch to video.

Additional automation would aid in the operational deployment of a USV system. Useful features would include auto-alerting on the sonar system, providing the operator with an audible signal when a target is initially detected; and auto-homing, connecting vehicle control with the sonar information. Other operational considerations include rapid launch and recovery and integration with existing security systems.

5.0 CONCLUSIONS

The USV program has effectively demonstrated the feasibility of using a ROV for the assessment of underwater targets. The USV system has been tested and used to detect, track, and intercept diver targets in an actual security setting. System recommendations include the addition of a wide angle sonar and a navigation system. In an operational environment, additional issues to be considered include the operator display, system automation, launch and recovery, and integration with other security systems. With these additions, the USV would be an effective operational security asset (figure 5).

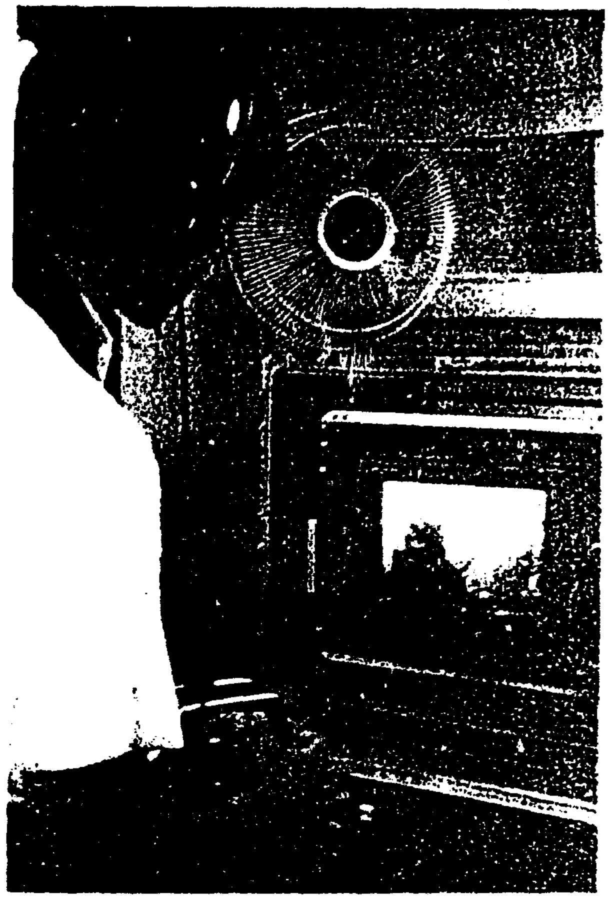

Figure 5: Vehicle Operation with Intercepted Target

REFERENCES

Fletcher, B., C. Keeney, and K. Kenworthy. 1990. "Physical Security Applications for ROV Technology," Intervention '90/ROV '90 (25-27 June), Marine Technology Society, Washington, DC.

Nobunaga, B., and B. Fletcher. 1991. "Underwater Security Vehicle Demonstration Test Report," NOSC Technical Document 2063, Naval Ocean Systems Center, San Diego, CA.

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